Machine Protection System

- **Run Permit System (Software Based)(1 second)**
  - » **Coordinates machine mode changes.**
  - » **Scans IOC configurations for Software Configuration errors.**
  - » **MPS interface for masking equipment inputs.**

- **Beam Permit System (Next beam pulse, (20 microseconds))**
  - » **Latches fault conditions until fault clears and Operator resets condition. BEAM_PERMIT_LINK carrier interrupted and inhibits beam through front end devices.**

- **Fast Protect System (20 microseconds)**
  - » **Inhibits beam for duration of macro pulse by disabling FAST_PERMIT_LINK carrier to the front end. Restores Fast Protect link for next pulse if fault restored to normal.**

Beam Permit System

- **Concentrates Permit Inputs**

- **Inhibits carrier link to disable beam – Operator Reset required to continue beam operations**

- **Devices bypassed by Key or PLC**

- **Inputs disabled by machine mode (event link)**

- **Equipment maintained in locked racks**

- **Documentation control of changes**

- **System verification after changes**

Beam Permit Inputs

- **Power supply Enabled status**
- **Magnet Current Comparators**
- **Valve Status**
- **RF Status**
- **Target Status**
- **Dump Status**
- **Timing System Status**

- **Vacuum Status**
- **Loss monitors**
- **Current monitors**
- **HARP**
- **SEM**
- **Beam Position Monitors**
- **Beam Loss Accounting system**
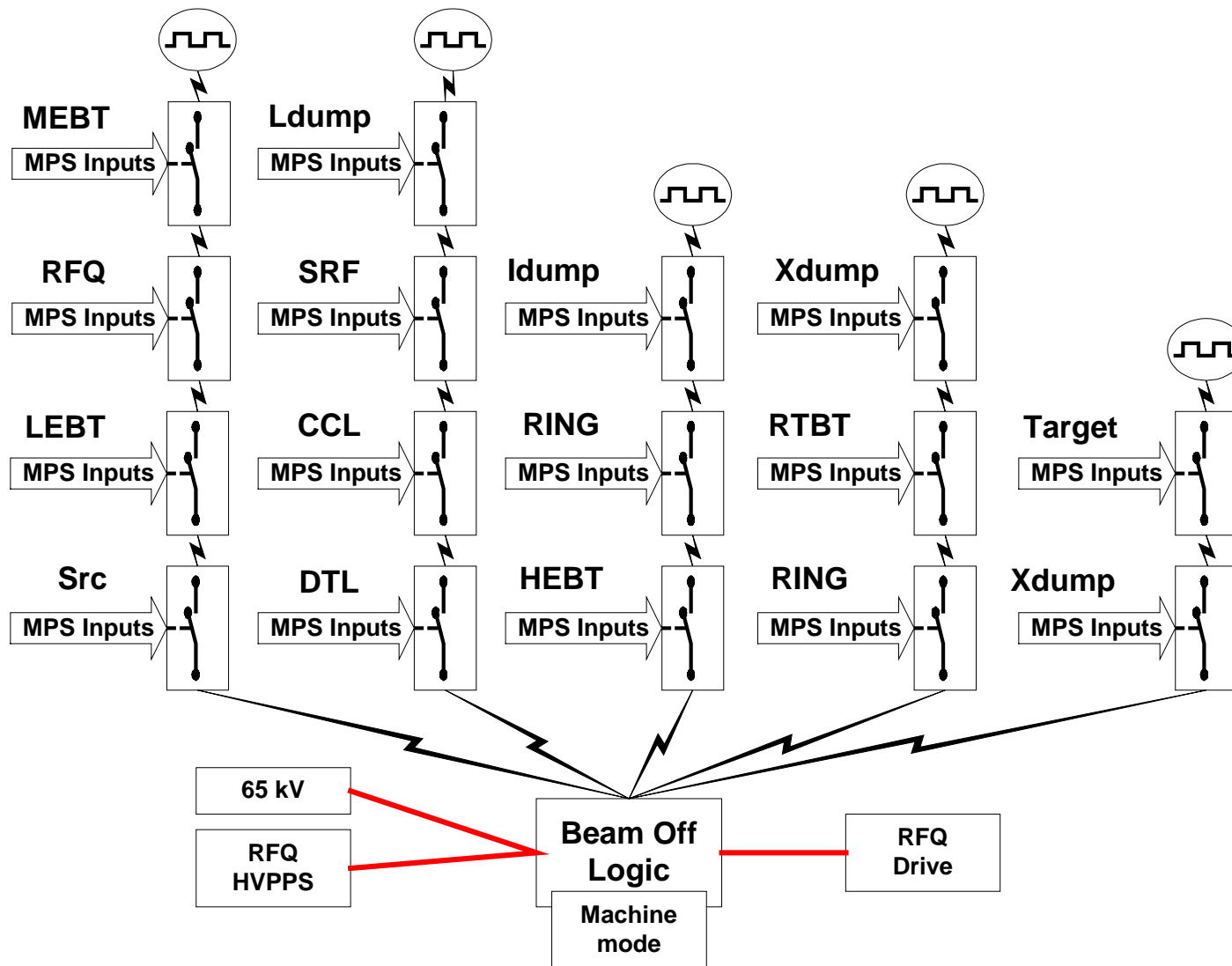
Fast Protect System

- **ALARA – Pulse Width Modulation**

- **Concentrates Permit Inputs**

- **Inhibits carrier link to disable Beam**

- **Inputs:**
  - » **Loss Monitors**
    - – **Software trip points, bypass**
  - » **Beam position monitors**
    - – **Software trip points, bypass**
  - » **RF Low level Controls**
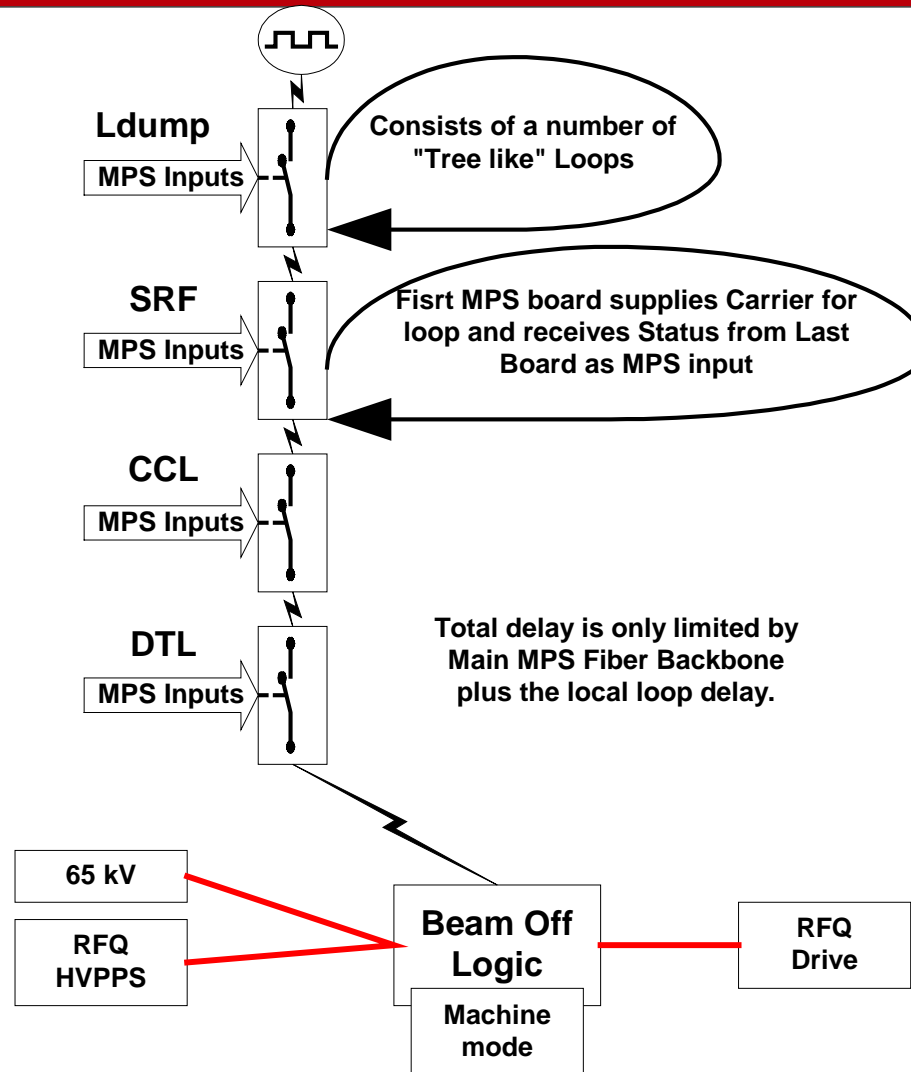
Automated Checkout Procedure

- Goal – Complete system checkout within 4 hours

- Check at sensor level when practical
  - » Inject current through toroid
  - » Current surge with high voltage ON (Loss monitors)

- Database (For each MPS input)
  - » MPS:Test_Signal
  - » MPS:Reset

- Run Permit Sequencer Code
  - » For each PPS area
  - » Caput MPS:Trip_Signal START
  - » Verify Front End Shutdown
  - » Caput MPS:Reset_Signal DONE

Machine Protection System Links

MEBT — MPS Inputs

Ldump — MPS Inputs

RFQ — MPS Inputs

SRF — MPS Inputs

Idump — MPS Inputs

Xdump — MPS Inputs

LEBT — MPS Inputs

CCL — MPS Inputs

RING — MPS Inputs

RTBT — MPS Inputs

Target — MPS Inputs

Src — MPS Inputs

DTL — MPS Inputs

HEBT — MPS Inputs

RING — MPS Inputs

Xdump — MPS Inputs

65 kV

RFQ HVPPS

Beam Off Logic

Machine mode

RFQ Drive

SNS Integrated Control System

MPS Layout – Loops confined by Machine Mode

Ldump

MPS Inputs

Consists of a number of "Tree like" Loops

SRF

MPS Inputs

Fisrt MPS board supplies Carrier for loop and receives Status from Last Board as MPS input

CCL

MPS Inputs

DTL

MPS Inputs

Total delay is only limited by Main MPS Fiber Backbone plus the local loop delay.

65 kV

RFQ HVPPS

Beam Off Logic

Machine mode

RFQ Drive

SNS Integrated Control System

MPS Carrier Cable Delays

IDump

Ring

5.84 us

7.27 us

Source
LEBT
RFQ
MEBT

3.08 us   **3.77 us**   **4.74 us**   **4.47 us**

DTL   CCL   LB-SRF   HB-SRF   HEBT

RTBT
7.23 us

XDump   Target
8.21 us

LDump

2.10 us   **3.87 us**   **4.12 us**   **4.34 us**

Delay = Trunk delay + MPS Brd Delay + Local Loop Delay

Control
Room
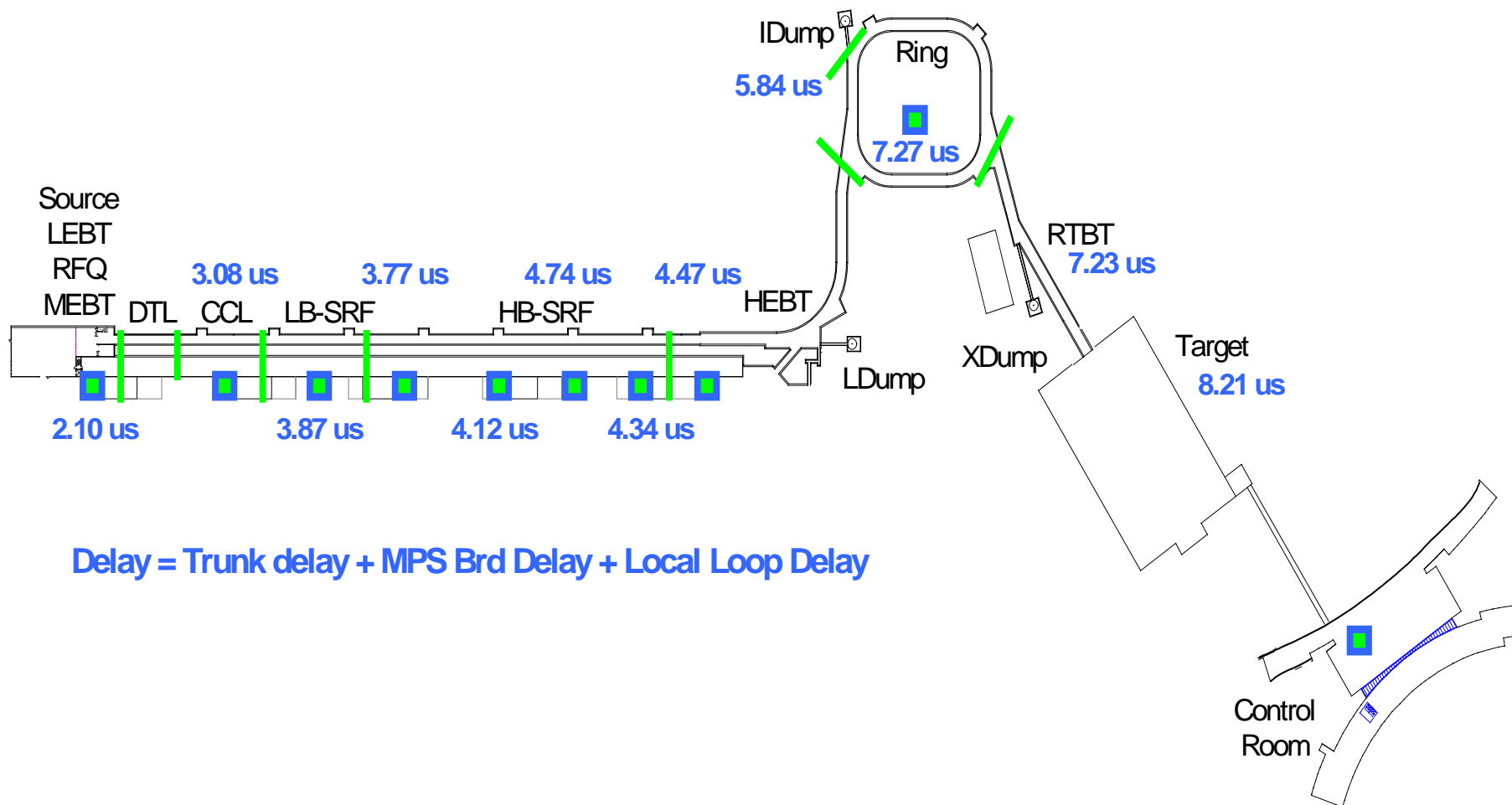
HEBT, Ring, RTBT MPS Layout considerations

Linac Dump Mode

- Some HEBT devices, Ldump devices

» Injection Dump Mode

- HEBT, Some Ring Devices, and Idump devices

» Extraction Dump Modes

- Ring, Some RTBT Devices, and Xdump devices

» Target Mode

- Ring, RTBT, and Target Devices

MPS Chassis Inputs (Per System)

- **Eight (8) positive true, fail-safe beam permit inputs.**

- **Eight (8) positive true, fail-safe fast protect inputs.**

- **One (1) 8 MHz carrier input, on-off modulation; beam permit link.**

- **One (1) 3 MHz carrier input, on-off modulation; fast protect link.**

- **One (1) 16 MHz carrier, bi-phase-mark modulated input event link.**

- **One (1) 10 MHz carrier, bi-phase-mark modulated input Real Time Data Link (RTDL).**

- **One (1) positive true, fail-safe PLC card bypass.**
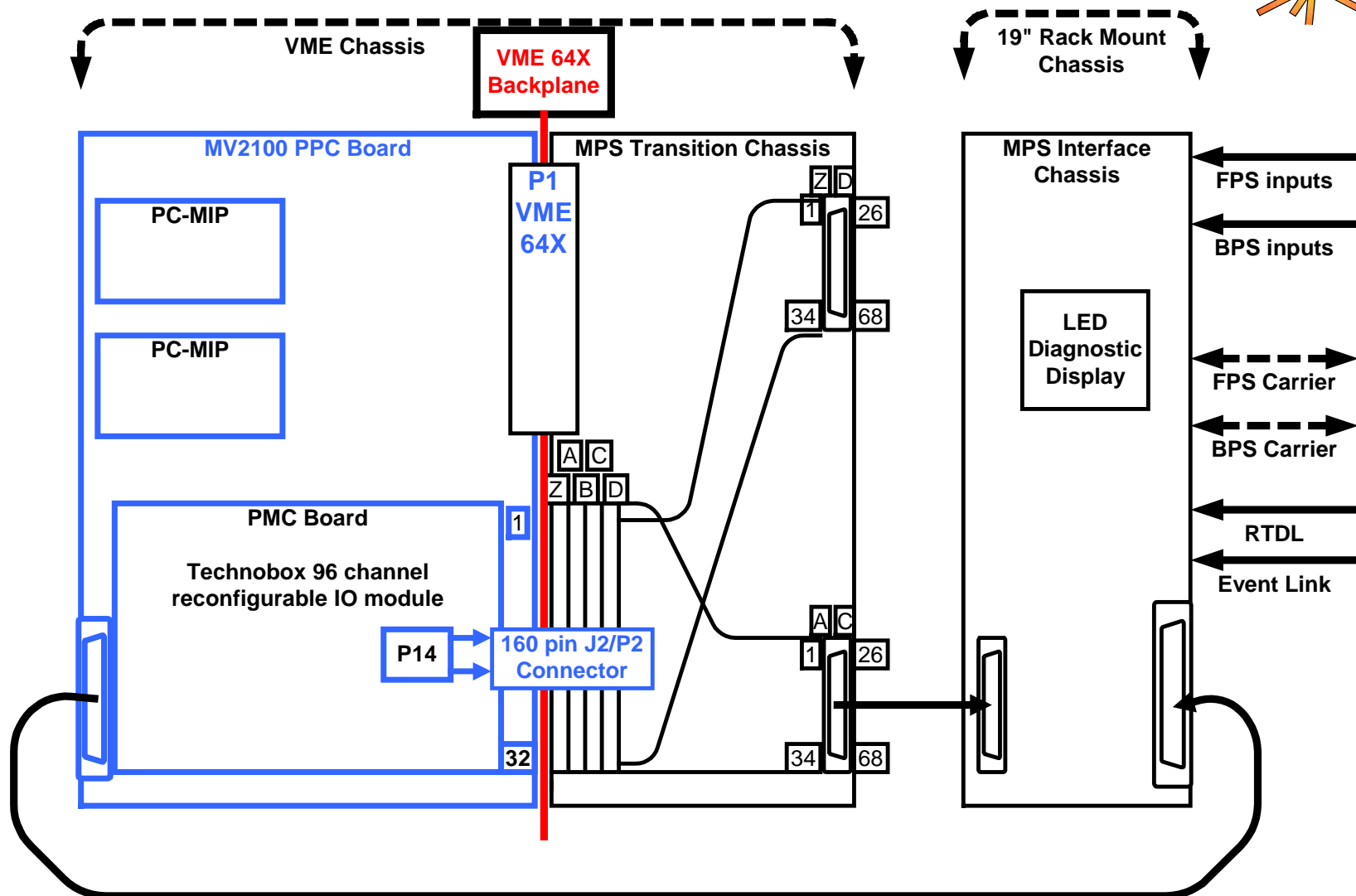
MPS Module Outputs (Per System)

- **One (1) 8 MHz carrier output, on-off modulation; beam permit link.**

- **One (1) 3 MHz carrier output, on-off modulation; fast protect link.**

- **Two (2) positive true, fail-safe, level output, local beam permit status.**

- **Two (2) positive true, fail-safe, level output, local fast protect status.**

- **One (1) positive true, fail-safe, level output, EVENT_LINK input status.**
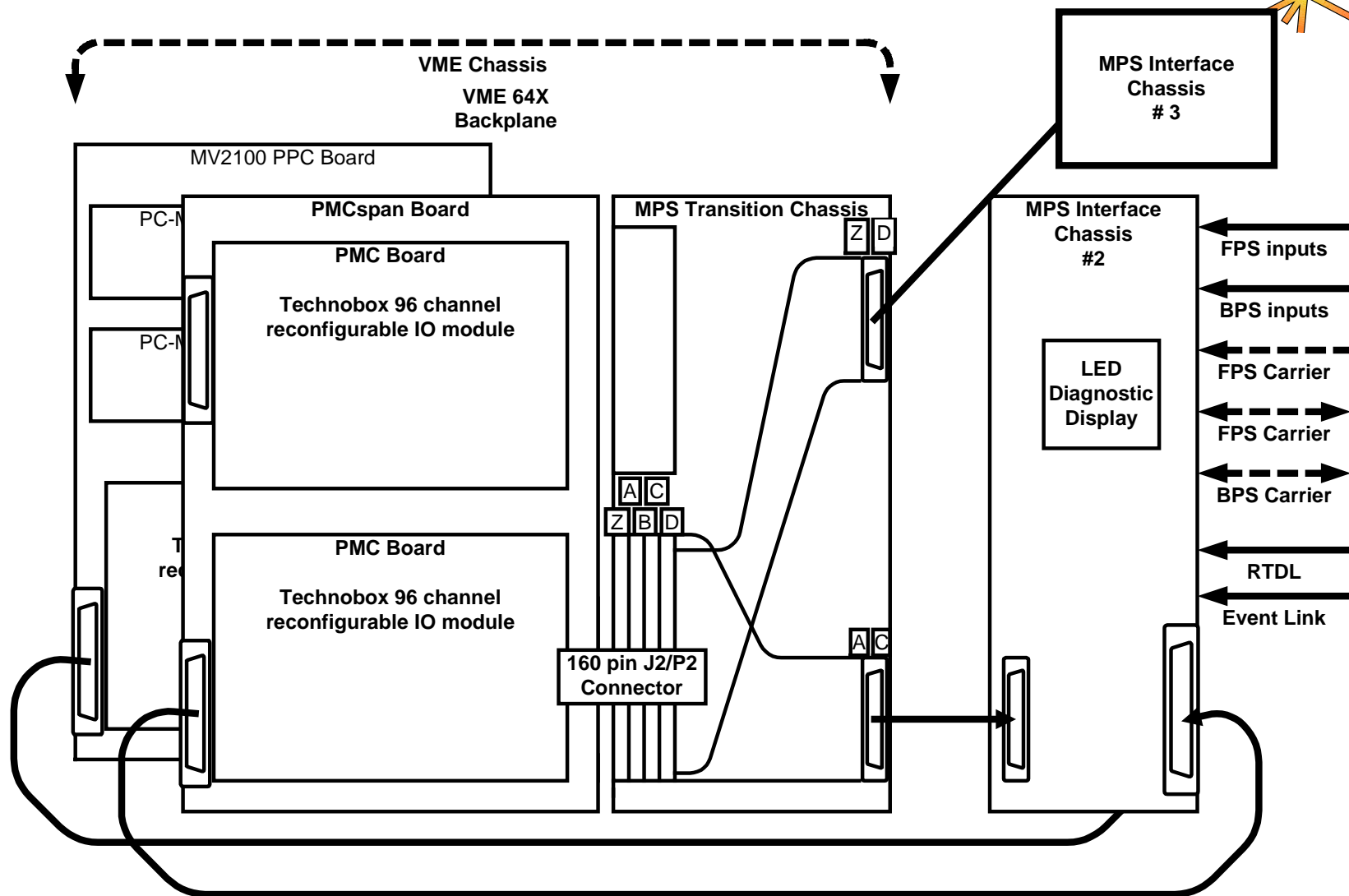
MPS Hardware 3 Component

- MVME PPC 2100 – Uses PMC slot for Digital IO. Contains Digital Logic, Fault Timers, Interface Registers

- PMCspan – Motorola PMC expansion board. Used to add 2nd and 3rd MPS systems if required.

- P2 VME Transition Module – Routes P2 connections to 50 pin SCSI connector(s)

- MPS Interface Chassis – Interfaces MPS input signals, Carrier links, RTDL and Event Links to the PMC card for processing.
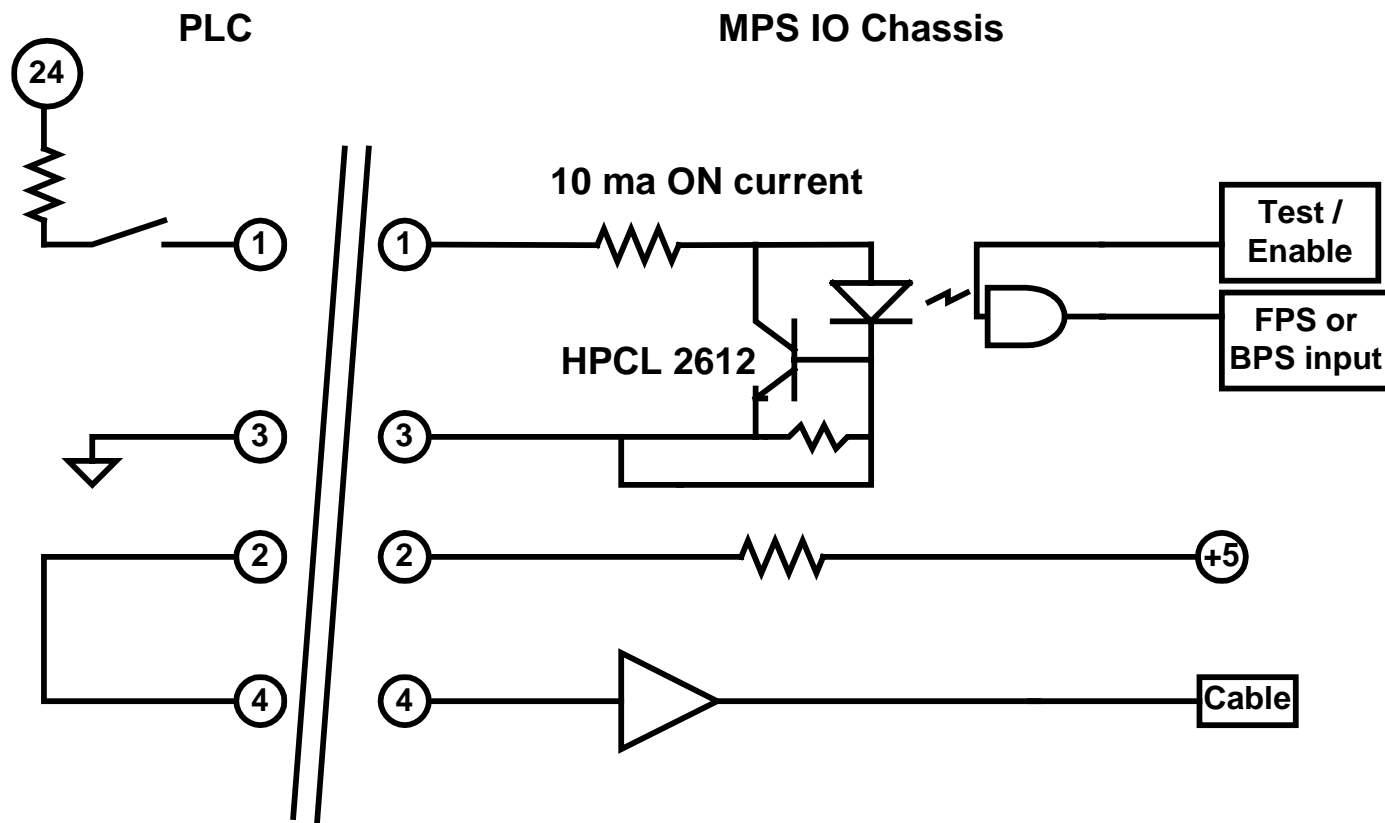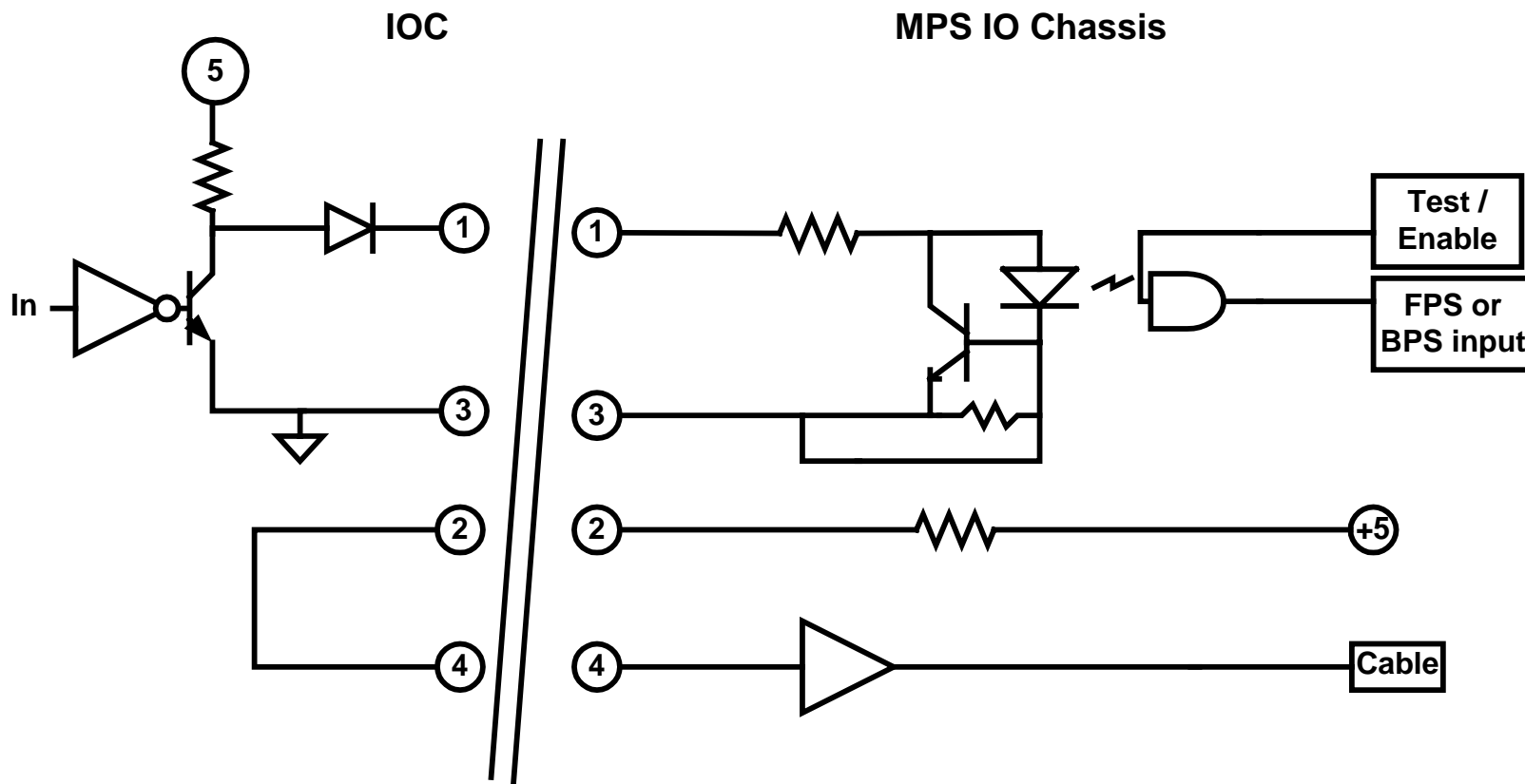
MPS Hardware

VME Chassis

VME 64X Backplane

19" Rack Mount Chassis

MV2100 PPC Board

PC-MIP

PC-MIP

P1 VME 64X

MPS Transition Chassis

Z D
1 26
34 68

A C
Z B D

PMC Board

Technobox 96 channel reconfigurable IO module

1

P14

160 pin J2/P2 Connector

32

A C
1 26
34 68

MPS Interface Chassis

LED Diagnostic Display

FPS inputs

BPS inputs

FPS Carrier

BPS Carrier

RTDL

Event Link

SNS Integrated Control System

VME Chassis

VME 64X Backplane

MV2100 PPC Board

PC-M

PMCspan Board

PMC Board

Technobox 96 channel reconfigurable IO module

PC-M

MPS Transition Chassis

Z | D

A | C
Z | B | D

PMC Board

Technobox 96 channel reconfigurable IO module

160 pin J2/P2 Connector

A | C

MPS Interface Chassis # 3

MPS Interface Chassis #2

LED Diagnostic Display

FPS inputs

BPS inputs

FPS Carrier

FPS Carrier

BPS Carrier

RTDL

Event Link

SNS Integrated Control System

MPS Input Circuit - PLC

PLC

MPS IO Chassis

24

10 ma ON current

Test / Enable

FPS or BPS input

HPCL 2612

1

3

2

+5

4

Cable

SNS Integrated Control System

MPS Input Circuit - IOC

IOC

MPS IO Chassis

In

5

1

3

2

4

1

3

2

4

Test / Enable

FPS or BPS input

+5

Cable

SNS Integrated Control System

VMIC 2330 Digital OP module
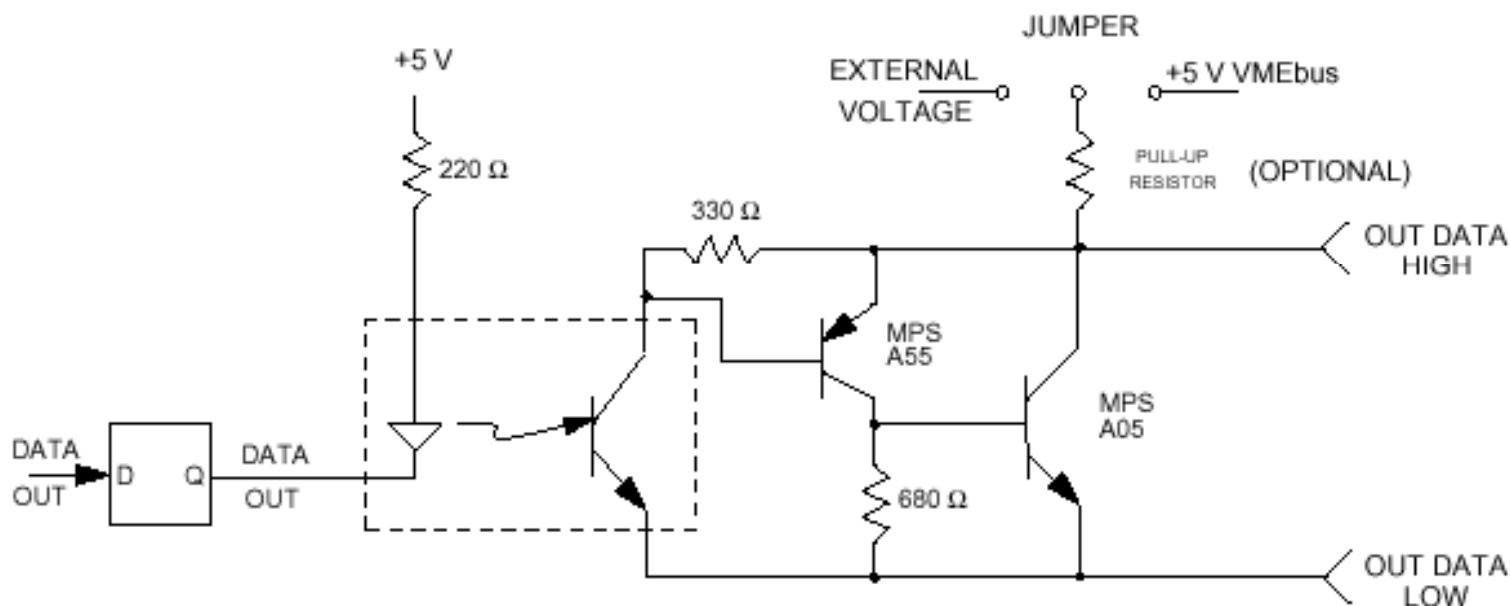
Figure 2. Typical Output Configuration

MPS Input Channel (fast protect or beam permit)

SNS Integrated Control System
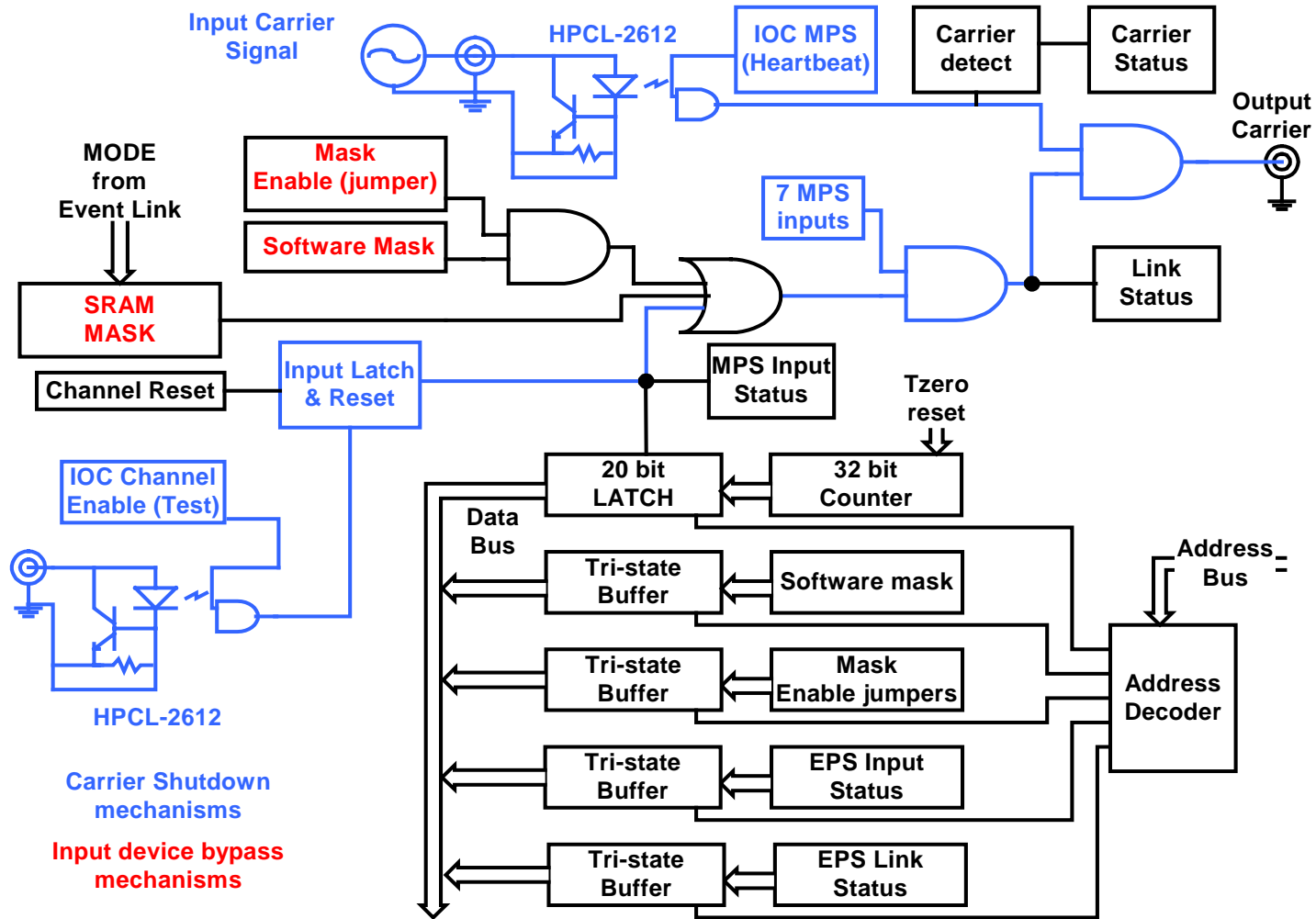
MPS Shutoff Equipment

- **Fast Protect**
  - » **RF drive to RFQ**

- **Beam Permit**
  - » **65 KV Power supply**
  - » **RFQ Power Supply**

- **Run Permit**
  - » **Fast Protect**
  - » **Beam Permit**

- **(Beam Abort - Extraction Kickers)**

- **(Event System (Abort signal))**

Ring MPS Devices

- **Vacuum System**

- **Extraction Kickers**

- **Collimators Motion, Temperature**

- **Stripper Foils – Integrity, Motion**

- **Timing System Status**

- **Ring RF System**

- **DCCT current sensors**

- **Integrating current monitors**

Vacuum System MPS inputs

- Valve Controls (~1 msec response from time valve starts to close)

- Vacuum Pumps (Slow Response, seconds)

- Vacuum Levels Beam can be allowed to run for different periods of time depending on the vacuum levels. Will co-ordinate with loss monitors.
  - » 10^{-6} ASAP
  - » 10^{-7} ?   Many instabilities
  - » 10^{-8} ?   Limited Running
  - » 10^{-9} OK

- USE SNS PLC Programming Standards

- MPS Test Functions programmed in to PLC code

- PLC can SUM MPS inputs within the same Machine Mode Zone

Extraction Kicker issues

- Kicker Charging Power Supply Status

- Kicker Ready Status – pulse to pulse – MPS input triggered by Tzero Event?

- False firing – Abort ASAP

- Beam Abort, Fault – ASAP verses waiting until "Normal" extraction time? Separate hardware input triggers? Different Events?

- 1 Kicker off line

- Extraction timing – Defined from Tzero "Event" on event link

SNS System Timing Cycle
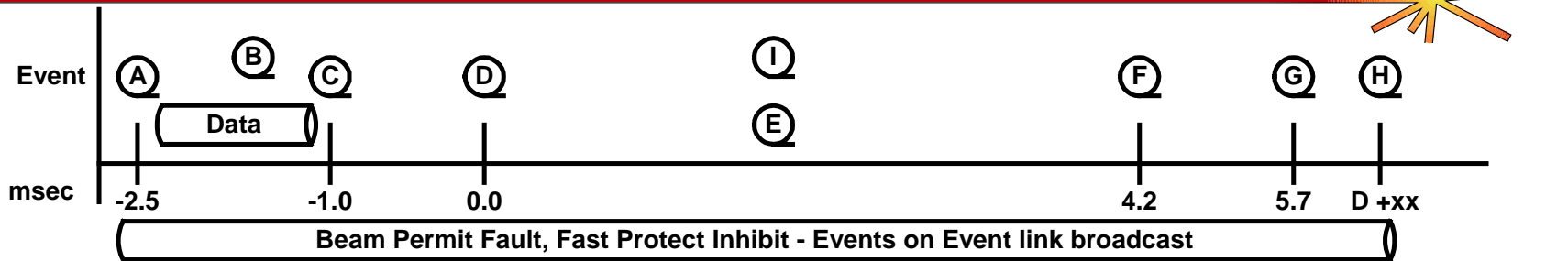
A. **Start of Cycle (Also End of Cycle)**

- **Previous pulse information sent out (RTDL)**
- **Information about next pulse sent out (RTDL)**
- **Time Stamp sent out (RTDL)**

B. **Information Events**

- **Mode information sent out (Event link) – One of 32 predefined beam modes, indicating pulse type and beam line (dump) in use.**

- **Synchronous Events – 1 Hz, 10 Hz, Snapshot**

C. **RTDL data valid – Hardware can load registers with data from the RTDL**

D. **Tzero – All time stamp registers loaded, fast counters initialized. Parameters for the next pulse are frozen.**

E. **Beam Permit Faults, Fast Protect aborts, and beam veto's can come at any time.**

F. **Beam inject – Injection cycle starts**

G. **Injection complete or Beam off.**

H. **Extraction – From 10 turns to 1000's of turns after injection cycle complete, nominally 10 turns.**

I. **Subsystem specific events for subsystem synchronous triggers, trouble shooting, etc.**

SNS Integrated Control System

Kicker Abort Signals, Event link and/or Hard wired

SNS Integrated Control System
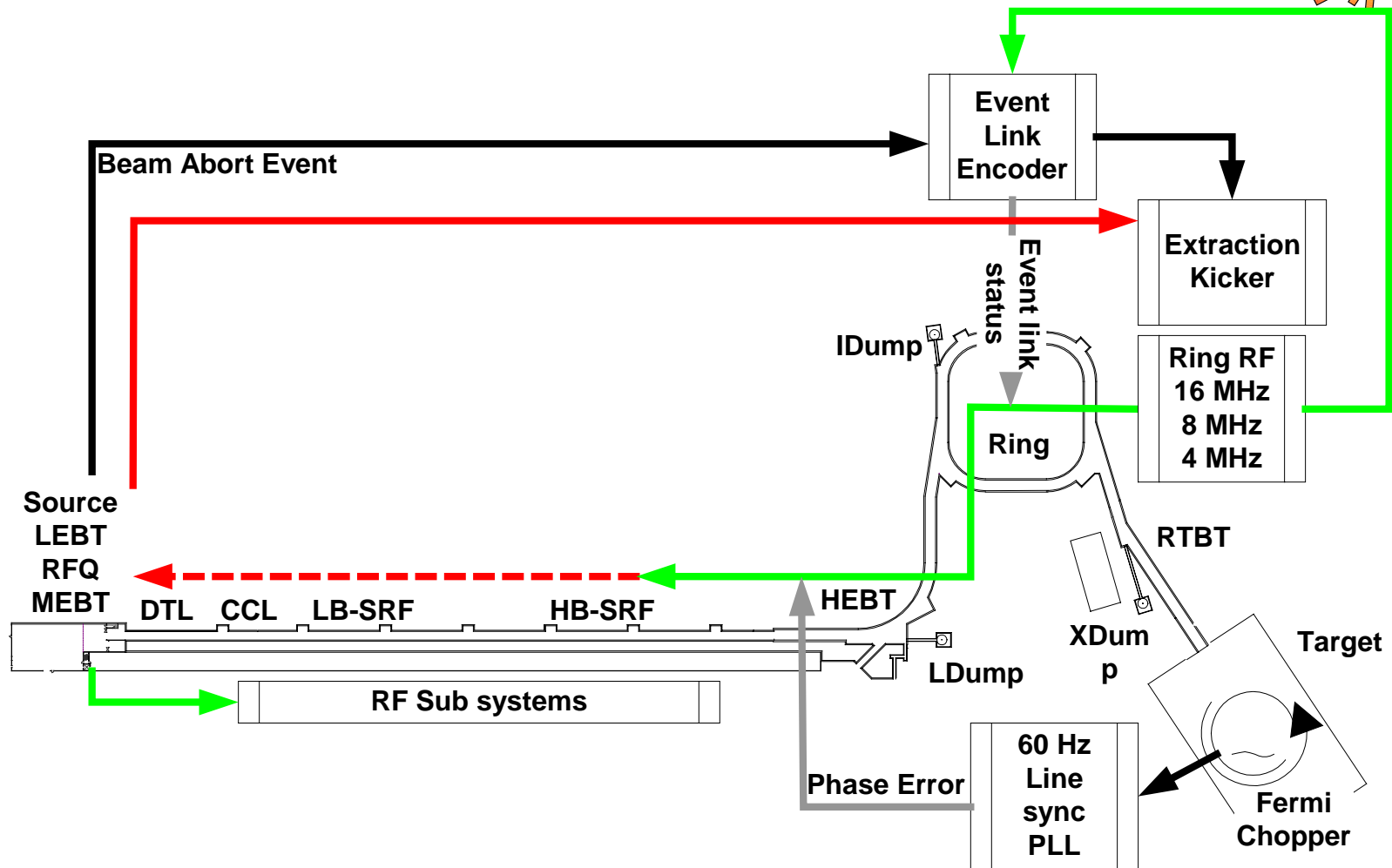
Ring Collimator MPS Inputs

- Temperature sensors

- Water Flow ?

- Normal loss monitors? (Dynamic range OK?)

- Motion – (Drop to lower beam power?)

- Motion out of range (LVDT's?)

- Limit Switches

Injection Foil

- **Foil Failure**
  - » Beam Loss Monitors
  - » HARPS
  - » Integrating Current Monitor
  - » Peak Current Monitor
  - » Foil Video monitor

- **Foil Motion –**
  - » Low power mode required?
  - » LVDT – Motion range available
  - » Limit Switches

Ring RF MPS Considerations

- RF Power Supply

- RF Cavity Field Error Signals

- Reflected Power

- RF Phase Error monitoring

- RF – Beam phase monitoring?

- RF Power Ramping (Amplitude modulation?)